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STUDIES FOR STUDENTS.

THE DEVELOPMENT AND GEOLOGICAL RELATIONS OF THE VERTEBRATES.

III. REPTILIA—(*Continued*).

ICTHYOSAURIA.

The *Icthyosauria* or *Icthyopterygia* were large marine reptiles fish-like in their external appearance, with the body and limbs modified to serve the purposes of the animal in its aquatic life. The head terminated in front in a long and powerful snout armed in most cases with sharp conical teeth set in a single common groove which bordered the jaws. The skull was flattened above and the eyes were large and protected by a ring of bony plates, the sclerotic plates. The body was naked or covered with fine scales that are never preserved in the fossil forms. The vertebræ of the tail were abruptly bent downward at the extremity. This is very peculiar because in most fossil forms in which the bending of the tail occurs, the bend is upward. The external form of the tail was as in the modern fishes. There was a dorsal fin as in the fishes and the limbs were converted into paddles with a large number of phalanges.

The *Icthyosauria* were long considered as the most primitive of the reptiles because of the general appearance of the body which is so fish-like and because the paddles were considered as the direct modification of the fish fin. The bones of the upper arm and leg are so short and the carpal and the tarsal bones are so simple, being mere disks of bone, that they were regarded as the first steps from the basal segments of the fin, while the numerous phalanges were regarded as the segments of the fin rays. Now, however, there is every reason to regard the *Icthyosauria* as the specialized descendants of land-living forms.

The degeneration of the limbs and the phalanges is exactly the same as took place in the mammals that have become aquatic in their habits ; the seals, walruses and the whales.

The *Icthyosauria* are known only from the marine rocks of the Mesozoic time and chiefly from the Liassic division. Specimens are known from North America, Europe and England ; Queensland, Australia ; New Zealand and the East Indies.

Mixosaurus, from the Triassic of Besamo in Italy, is one of the oldest as well as one of the most important of the group. The animal was small, about three feet long, the head was proportionately long and there were few teeth ; the legs were long and well developed, typically those of a land-living form.

Icthyosaurus.—This genus contained a very large number of species ; it is generally divided into two groups, the *Longipinnati* and the *Latipinnati*, accordingly as the limbs, which in the whole genus have been reduced to the condition of paddles, are long and slender with few, five or less digits, or broad and short with more than five digits. Typical of the first division are: *I. quadricissus*, *I. tricissus*, *I. tenuirostris*, *I. longifrons*, etc. ; of the second group, *I. communis*, *I. trigonus*, *I. leptospondylus*, etc.

The genus is found most commonly in the rocks of the Lias. From the Wellendolomite of the Black Forest and the Muschelkalk of Crailsheim of Wurtemberg comes one of the oldest as well as one of the largest of the genus, *I. atavus*, about thirty feet long. From the Trias of Spitzbergen have been collected two species, *I. polaris* and *I. Nordenskioldi;* the first was very large, while the second was much smaller. From the Lias of England come the best preserved specimens that we have. Especially is this true of the Lyme-Regis region of Dorsetshire. *I. communis* from this region belongs to the first division, the *Latipinnati;* it was one of the largest of the genus. To the same division belong from this region : *I. intermedius* and *I. breviceps;* to the second class, among others : *I. platyodon* and *I. tenuirostris*. The first was a giant even among these large forms, but the second was quite small and delicate in structure. The paddles had only three digits or rows of phalanges. The skull was very long and slender and the jaws were slender and curved. The whole animal was about twelve feet long.

The continental forms come almost entirely from the Upper Lias, the Poisodonomyen-Schiefer. In Germany large numbers of most excellently preserved forms are obtained from near the small towns of Boll, Holzmaden, Ohmden, etc., at the foot of the Swabian Alps, and from the neighborhood of Banz in France. Many of the forms obtained from these localities are specifically identical with the forms from the English deposits. From the Cretaceous layers of Trichinopolis in the East Indies, and from about the same horizon of the same age in New Zealand and Australia have been collected specimens of this genus. From the Island of Gozo near Malta come fragments from layers that appear to be Miocene; if this is correct, the genus extends very much farther in time than was originally supposed, but the remains are only fragments and the age of the strata is still in doubt.

Opthalmosaurus from the Upper Jurassic of England is known only from a few fragments, but is interesting from the fact that the jaws were entirely without teeth. The paddle was broad and stout with many small phalangeal bones.

Baptanodon is from the Upper Jurassic of Wyoming. This genus was also without teeth. The paddle was very broad and the phalanges very numerous.

The great geographical range, and the large number of species indicate the extensive development of these animals in the short time that they existed on the earth. That they were fierce and predaceous is amply shown by the remains of fish scales and bones that are found in the coprolites.

SAUROPTERYGIA (*Plesiosauria*).

Aquatic reptiles, generally of large size, with long necks and heads of comparatively small size; the body very short and stout, ending in a long and powerful tail; the orbits were very small and the posterior portion of the skull shows a single temporal arch. The teeth were sharp and strong, conical in form and often recurved; they were set in separate sockets or alveoli. The pectoral and the pelvic girdles in the most advanced of the group were greatly expanded to serve as a protective shield for the thoracic and the abdominal regions.

The *Plesiosaurs* descended from land-living animals with well developed limbs just as the *Icthyosaurs* did. In the earliest of the *Plesiosaurs* the fore and hind legs were those of an animal that walked on the dry land at least as well as the modern alligators, but in the later and more specialized forms, the limbs are reduced to paddles which were useless for any purpose but that of swimming. The general appearance of the brute has been aptly described as that of a "turtle strung on a snake."

There are generally recognized three families of the *Plesiosaurs:*

Nothosauridæ.
Plesiosauridæ.
Pistosauridæ.

Nothosauridæ.—These were small forms that were most nearly related to the parent form of the whole group. The limbs were more or less well adapted to progression on land and there were five functional digits on each foot.

Nothosaurus, from the Triassic (Muschelkalk) of Byreuth and from other parts of Germany and from the Tyrol and the Keupfer of St. Cassian in France, was one of the small forms. It was about nine feet long. The skull was long and flat. The orbits were small and were located in the middle portion of the skull. The temporal fossa was quite large, taking up the posterior third of the skull.

The anterior nares were small and located far forward but not at the extremity of the rostrum. The teeth were numerous, small, and of nearly equal size in the posterior portion of the jaws, they formed large recurved tusks in the fore part, and were set far apart. There were 20 cervical vertebræ, 25–30 dorsals, and about the same number of caudals.

Closely related forms from the same horizon, that are known only from fragments, are *Chonchiosaurus*, *Simosaurus* and *Lamprosaurus*.

Lariosaurus was very much smaller than *Nothosaurus*, being less than 3 feet in length. It is known from the Trias (Muschelkalk) of Italy. The skull is triangular in outline and very much shorter than the skull of the first genus. The temporal fossæ are large, the orbits and the nares small and lying quite close together. There were 20–21 cervical vertebræ, 24–26 dorsal, and about 30 caudals. There was in this genus, as in the former, a ventral armor of small abdominal ribs.

Pachypleura, from the Trias of Italy, was very similar to *Lariosaurus*, but was even smaller. It was remarkable for the length of the tail which was nearly half as long as the body. There were about forty vertebræ in the tail. The same genus is known from the Trias of Germany.

Plesiosauridæ: large forms with the limbs developed as paddles. There were five digits on each foot, but the number of phalanges is much above the normal. The whole pectoral girdle reaches a very great development in these forms so that it forms a bony protection for the thoracic region.

Plesiosaurus.—The head of this genus was small and rather elongate, the temporal fossæ were large and the orbits and nares small. The teeth were numerous in both jaws. They were long and slender, slightly recurved and set in deep alveoli. They were somewhat large at the anterior end of the snout. The neck in some of the species of the genus, was as long as the rest of the body. There were 20–72 cervical vertebræ, 20–25 dorsals, and 30–40 caudals. There was a system of abdominal ossicles consisting of a centerpiece and two or more smaller lateral pieces. The most characteristic part of the anatomy of the animal is the pectoral girdle. The coracoids became very large and the clavicles reduced to small proportions. The extension of the coracoids of the two sides causes them to meet in the median line and they together join the clavicles and the interclavicle in front, making a thick bony cuirass covering the region. The pelvis does not show such a great expansion, but there is a considerable development of the pubis, that parallels to some extent the extension of the coracoids.

The oldest known remains of this genus come from the Rhaetic beds of England and France (Autun). The most plentiful deposit is in the Lower Lias of Lyme-Regis in England; there are about twenty-six species known from these beds, a much larger number than is known from the continent. The continental forms are found most commonly in the Lias beds in the vicinity of Holzmaden in Germany and near Banz and Autun in France.

Eretmosaurus is quite similar to *Plesiosaurus*, being distinguished only by the greater development of the thoracic shield. A headless skeleton preserved in the British Museum is about nine feet long.

Cimoliosaurus from the Cretaceous of the United States is characterized by the complete loss from the pectoral girdle of the clavicles and the interclavicle. The scapulæ and the coracoids are extended until they meet the bone of the opposite side in the median line for a long distance and join each other in a broad suture. The whole arrangement is the most specialized of any in the group, both in the loss of the two elements and in the size of the coracoids and the scapulæ. Many similar forms that show the same thing, but with slightly different shaped bones, have been described as different genera, but were all united by Seeley in the genus *Cimoliosaurus* of Leidy. These genera are *Discosaurus*, and *Brimosaurus*, from the same horizon of the Cretaceous in Alabama and New Jersey as the original genus; *Polycotylus* from the Cretaceous of Kansas (Niobrara); *Elasmosaurus*, from the same locality and horizon as the last, is of remarkable length, one specimen from near Fort Wallace in Kansas being 45 feet long, the neck alone being 22 feet and containing 72 vertebræ; *Mauisaurus*, from the Cretaceous of New Zealand.

A summary of some of the different forms referred to this genus will give some idea of the importance it attained in the latter part of the Mesozoic time.

Cimoliosaurus, Cretaceous of New Jersey and Alabama.

C. (*Polycotylus*), Cretaceous of Kansas.

C. (*Mauisaurus*), Cretaceous of New Zealand.

C. (*Elasmosaurus*), Upper Cretaceous of Kansas.

C. (*Plesiosaurus*) *helmerseni*, Gault of England and Russia.

C. (*Plesiosaurus*) *planus*, Gault of England, Russia, and France.

C. (*Plesiosaurus*) *australis*, Cretaceous of New Zealand and Australia.

C. (*Plesiosaurus*) *chilensis*, Cretaceous (?) of Chile.

The *Plesiosaurs* were powerful, free-swimming, predaceous animals that found their chief food supply in the fishes and the smaller reptiles that inhabited the same waters. The long neck and powerful teeth must have made them more than a match for any of the aquatic forms of the time, and the fish-like form and the strong paddles enabled them to get through the water with great velocity. In no other form of this time do we find such great variety of forms and such wide geographical distribution; the only region in which their remains have not been found is South Africa. A most interesting habit of the animals was the swallowing of stones, apparently to aid in the digestive work of the stomach. One specimen from the Fort Benton Cretaceous of Kansas had about 125 of these stones in the stomach, varying in size from that of the fist to that of a pea.

Thaumatosaurus, from the Jurassic (Dogger and Kimmeridge) of England and India (Gonwanda series), and also from the Jurassic of Wurtemberg, was a peculiar form with a very large head supplied with strong teeth and a very short neck. The limbs were proportionately quite long and the bones of the proximal series were better developed than common in the *Plesiosauridæ*.

Peloneustes and *Pliosaurus* are from the Cretaceous of England. The last was of gigantic size, the skull of one being over 4 feet 9 inches in length and 2 feet 11 inches across the posterior end. The neck was rather short having only about 20 rather compressed vertebræ.

Pistosauridæ: the skull, elongate and terminating in a sharp rostrum in front; the anterior nares, very small and formed by the maxillaries and the premaxillaries; the nasals, greatly reduced and taking no part in the nares; a single foramen in the palate at the anterior end, forming the posterior nares or choanæ.

Pistosaurus is the single genus; from the Muschelkalk of France and Germany.

PYTHONOMORPHA.

The *Pythonomorpha* are specialized forms of the *Lacertilian* branch developed during Cretaceous time. They were sea-living lizards, corresponding in many particulars to the popular idea of the sea serpent. They were greatly elongated in form, the limbs were specialized as paddles, and the whole body adapted to an aquatic life. They resembled the living *Varanus* or *Monitor.* The head was long and flat; the eyes, small and located far back in the skull, were supplied with sclerotic plates. The major part of the skull was formed by the long jaws, which were furnished with sharp, conical teeth, straight or slightly curved backwards, and set in separate alveoli. The upper jaw was solid and strong, with or without a rostrum extending in front of the teeth. The lower jaw was not united at the anterior end with the jaw of the opposite side, but was attached to it by cartilage, thus allowing a great degree of freedom in the action of the two jaws. Moreover, the jaw of each side was furnished with a second joint at about the middle, which allowed the jaw to be bent out or inward in a horizontal plane, and enabled the animal to swallow the large animals upon which it preyed. The brain cavity was small, and the quadrate bone was joined to the skull loosely, as in the snakes, allowing the jaws to be opened very widely. There were a great many vertebræ, giving a great length to the neck and tail as well as to the dorsal region. The vertebræ were furnished with very perfect articular surfaces, concave in front and concave behind; besides the regular arrangement for the connection of the vertebræ there were accessory articular processes such as occur in the snakes, allowing a very great freedom of movement to the body. The limbs were modified as swimming organs. As in the case of land forms generally which have become adapted to an aquatic life, the number of the phalanges was increased, while the shape of these and of the tarsal and the carpal bones became indefinite, and, in some cases, they were even reduced to mere flattened disks of bone.

The geographical range of the *Pythonomorpha* is rather remarkable. They are known from the Upper Cretaceous rocks only, ranging from the Upper Dakota to the Lower Laramie. They have been found in the rocks of the western part of the United States, in Kansas and the Dakotas and in the Cretaceous deposits of New Jersey and Alabama; in the Maestricht beds, Lower Danian, of Belgium; in the Upper Cretaceous of England, the Chalkbeds, which are supposed to be correlated in time with the Niobrara beds of western Kansas; in Upper Cretaceous beds of unknown position on the coast of Chile and upon some of the adjacent islands, and in the same horizon in New Zealand.

The order is divided into three groups: the subfamilies *Tylosaurinæ*, *Platecarpinæ*, and *Mosasaurinæ*. Below is an abbreviated list of the characters assigned by Williston to the various divisions.

Tylosaurinæ: hind feet functionally pentadactyl; trunk short, tail proportionately long; tarsus and carpus almost wholly unossified, phalanges numerous; premaxillaries projecting as a long rostrum in front of the teeth.

Tylosaurus.—This is one of the largest of the forms. It reached in some cases, *T. dyspelor*, a length of nearly 30 feet. There were 7 cervicals, 29–30 precaudals, 80 caudals. From the Upper Cretaceous of New Zealand, Kansas, New Mexico, and New Jersey.

Hainosaurus: less well known; from the Upper Senonian of Cipley (Brown Phosphate Chalk) in France.

Platecarpinæ: hind feet functionally pentadactyl; trunk short, tail proportionately long; carpal and tarsal bones not well ossified; premaxillaries, not projecting in front of the teeth, obtuse.

Platecarpus.—This form was of intermediate size, one genus reaching a length of about 14 feet. Cervicals, 7; precaudals, 27–28; caudals about 80, probably somewhat less than in the *Tylosaurinæ.* From Kansas, Colorado, and Mississippi.

Plioplatecarpus: from the Maestricht of Belgium.

Taniwhasaurus: from the Cretaceous of New Zealand.

Mosasaurinæ: hind feet tetradactyl; carpus and tarsus fully ossified and with not more than six phalanges in each digit; trunk rather long with a shorter tail; rostrum short.

Mosasaurus: from Belgium, England, New Jersey, Dakota, Alabama, and North Carolina. Specimens from New Jersey show a length of 32–36 feet, and some of the European forms were as long as 40 feet.

Clidastes.—This was one of the smallest of the genera. *C. pumilus* was only about 6 feet long, and no species was over 12–14. Cervicals, 7; precaudals, 42; and caudals, 70. From Kansas, Colorado, New Jersey, Mississippi, and Alabama.

Many less well-known genera have been described from the rocks of this country and Europe, showing that the group had a considerable development while it lasted.

Speaking of the group, Williston says: "The food of the Mosasaurs must have consisted chiefly of fishes of moderate size with occasional victims of their own kind. While the flexibility and loose union of the jaws undoubtedly permitted animals of considerable size to be swallowed, the structure of the thoracic girdle would not have permitted any such feats of deglutition as the *Python* and *Boa* are capable of. The animals must have been practically helpless on land. They were not sufficiently serpentine to move about without the aid of limbs, and these were not at all fitted for land locomotion. They lived in the open sea, often remote from the shores. Their pugnacity is amply indicated by the many scars and injuries they received, probably from their own kind."

PTEROSAURIA.

The *Pterosauria* or *Pterodactyls,* as they are more popularly called, were reptiles that were adapted to a flying or soaring life in the air. Just as the preceding groups, the *Icthyosaurs* and the *Plesiosaurs* had been compelled by the great struggle between the large number of reptilian forms to seek some peculiar modes of life to maintain an existence and had taken to the water, so these forms had been compelled to seek new environment and became adapted to an aërial, or partially aërial, life. Whether they were possessed of any great power of flight or were only capable of soaring, as the flying-squirrel, is not known, but the enormous distance that their remains are found from what must have been the land at the time and the pneumaticity of their bones speak for a very well developed power of flight. There was great variation in the sizes of the animals, some being very small, while others reached a spread of 18 feet from tip to tip of the expanded wings. The bones were all hollow and provided with foramina at the extremities that seem to have filled the same function that the foramina in the bones of the birds do, that of supplying air to the interior of the bones. These two facts seem to imply that the Pterodactyls were warm-blooded, but this can not, of course be definitely settled from the skeleton. The tail was either long or short. In the cases where it was long, it ended in an expansion that served as a rudder to guide the flight of the animal. The fore limbs were very much longer than the hind limbs and were especially modified to support the organ of flight. This was a strong membrane much like that which serves the same purpose in the bats. In certain of the specimens preserved in the fine grained slates of the Solenhofen beds, the folds of the wings are preserved and even the course of the nutrient arteries may be followed. There were four digits on the front foot or wing, the last four, and the last of these, or the little finger, was enormously extended so that it was many times the length of the arm. The other fingers were short and greatly reduced in size; they ended in small claws which perhaps aided the animal to cling to the sides of the cliffs on which it lived. The wing membrane stretched from this extended finger and the arm to the weak posterior limbs. In all probability the membrane extended also between the hind legs and for a short distance out upon the tail. The head was very bird-like, all the bones being closely united and the sutures between them disappearing early in the life of the animal. The skull was of many different forms in the different species and the jaws were almost always furnished with teeth, but in some of the more specialized of the genera these were absent.

The group is generally divided into three families:

Pterodactylidæ.
Rhamphorynchidæ.
Pteranodontidæ.

Pterodactylidæ: forms with short tails; the skull quite long and furnished with teeth; the sides of the skull anterior to the orbits broken by vacuities that possibly aided in lightening the weight of the skull. The orbits were large and there was only one temporal arch. The metacarpals were longer than one half of the length of the forearm.

Pterodactylus was about a foot long and very slender in all of its proportions. The skull was long and bird-like and furnished with teeth at the anterior ends of the jaws only. There are many species of this genus known, the most of which come from the Upper Jurassic layers (Lithographic slates) of Germany, near Eichstat and Bayern. A few specimens have been taken from the Upper Jurassic of France in the department of Ain and the Kimmeridge clays of England have furnished isolated bones of the same genus.

Rhamphorynchidæ: forms with long tails which are frequently accompanied by ossified tendons; the skull only moderately elongate; the jaws furnished with teeth throughout their whole length which grew smaller towards the posterior part of the jaw, those in front being long and slender. Metacarpals shorter than the half of the forearm. The fifth toe of the hind foot taking some part in the support of the wing membrane and showing a much greater development than the other toes.

Dimorphodon, from the Lias of Lyme-Regis in Dorsetshire, England, was a much stouter form than the *Pterodactylus;* the head was short and high with strong teeth and small lateral vacuities. The whole animal had a length of nearly three feet.

Rhamphorynchus had a rather long snout, edentulous at the anterior end in both the upper and the lower jaws. The remaining portions of the jaws were filled up with rather long and slender teeth which were directed forward. The teeth were of different sizes in the jaws, but, in general, the largest were in the anterior part. The neck was short and strong and the cervical vertebræ very short. The sternum was broad and furnished with a median keel for the attachment of strong muscles as in the modern flying birds. The tail was long with 30–36 vertebræ and strengthened by tendons. The wing of this form was more slender than in the majority of the *Pterodactyls* and resembled that of the night hawk or goatsucker. The genus is known from the Upper Jurassic (Lithographic Slates) of Bayern and Wurtemberg.

Scaphognathus was much like the preceding, except that the teeth extended to the extremities of the jaws and were few in number. They were directed vertically instead of forward. Specimens of this genus are known from the Upper Jurassic of Germany and of England.

Ornithochierus is the name given to a very large form that is known from numerous fragments in the Jurassic deposits of England. The jaws seem to have been furnished rather sparsely with teeth of considerable size which extended to the extremity of the jaws. There are a great many species represented in the rocks of England from the Wealden to the Cretaceous, in all about 25. One form from the Chalk, *O. giganteus*, must have possessed a spread of wing of about 15–18 feet.

Pteranodontidæ: the skull long and terminating in sharp, edentulous jaws; no lateral vacuities in the skull; the tail, short.

Ornithostoma was originally described from the fragment of a jaw from the Chalk of England, but no more of it was known than that it was without teeth.

Pteranodon (?), from the Upper Niobrara, Cretaceous of Kansas, was a very large form with toothless jaws; probably synonymous with *Ornithostoma.* Head much elongate; the jaws slender, pointed and wholly wanting teeth; external nares and antorbital vacuities united; supratemporal fossa of large size; occipital crest elongated; the anterior dorsal vertebræ united and bearing a supraneural plate for articulation with the scapulæ; tail short and small; four functional toes on the hind foot.

Speaking of the general appearance of the animal, Dr. Williston says: "Altogether the skeleton of *Ornithostoma* presents some remarkable characters. I believe there is no other reptile in which the prosthenic features are carried to as high a degree as in this. The disproportion between the fore and hind extremities is almost ludicrous. The pelvis is exceedingly small, the legs not only small but weak in all respects. That the animal could have stood on its feet free on the ground I do not believe possible. The neck vertebræ are relatively stout, but the neck was not remarkably elongated, to carry such a head as the animal possessed. Furthermore, the remarkable mode of articulation of the neck and the anterior dorsal vertebræ seem to indicate a restricted range of torsion, though tolerably wide sagittal flexion. The occurrence of the remains of the large species in strata evidently formed remote from the shore lines, as shown by the absence of other animals, turtles, etc., indicates great powers of flight. Furthermore, it is rare that a single bone of a *Pterodactyl* is found unassociated with others, and almost invariably the wing bones are found more or less in connection, indicating either tough and horny tendons or a rapid sinking in the water, which might happen from the filling of the hollow bones with water through their pneumatic openings.

"Notwithstanding the enormous expanse of the wings, I do not think these animals could have weighed much when alive. I doubt very much if one of the largest species reached twenty pounds."

Nyctodactylus was a form from the Cretaceous of Kansas (Niobrara) that differed from the previous genus principally in the size, the wings measuring less than ten feet when expanded. The jaws were almost certainly edentulous.

TESTUDINATA.

The turtles may be briefly described as reptiles that have lost the teeth completely, and have developed an external skeleton in the shape of a bony case that is more or less complete and protects the body of the animal. There is little doubt that they are derived from animals that did not possess such a structure, but the point of their divergence from the primitive stem is so ancient that it has not yet been detected, and the oldest form that we know is a member of the most specialized group of the turtles.

The order is generally divided into three suborders:

Trionychia.
Pleurodira.
Cryptodira.

The *Tryonichia* differ from the typical forms of the *Testudinata* in that the bony exoskeleton is largely represented by a thick, leathery skin, which has given them the name of Soft-shell Turtles. Beneath this skin is developed a series of small bony plates with a characteristic sculpture, that in many places form the chief remains of the forms.

Trionyx is the most common of the extinct forms. The oldest remains are from the Upper Cretaceous of New Jersey; these are, for the most part, fragmentary remains of the plates of the carapace. From the Upper Cretaceous, Laramie, of the western part of the United States and British America, have been collected a large number of specimens. Through all the deposits of Tertiary age in Europe, specimens of this genus have been found; in the United States it is found throughout the Tertiary of the eastern part, but in the west seems to be confined to the lower layer, the Eocene. Remains of still living species have been found in the Pleistocene beds of India and Burmah.

The *Cryptodira* are by far the most important group of the Testudinata, both in number of species and their distribution in time. The group is characterized by the fact that the pelvic bones are not anchylosed to the carapace and the plastron above and below. There were developed so many forms that it is impossible to consider more than a few of the genera. There seems to be a division of the group in very early times into land-living and water-living forms. The first of these gave rise to the common swamp and land turtles of today, and the second group to the sea turtles, the *Pinnata*.

The second of these groups may be considered first; *Dermochelys* is the most specialized of the genera. This is a gigantic form still living in all of the oceans, though little known from its almost exclusively pelagic habits. The carapace has entirely disappeared and is replaced by a tough leathery skin that has won for them the name of "Trunk-backs or leather-turtles." The plastron is less completely removed but there is a large space in the center, between the bones called the fontanelle. The fore limbs are developed as flippers, the anterior pair being much the longest.

The more common members of the same division are the Loggerhead and Green turtles. In these the carapace and plastron are less reduced, but both show large vacuities that indicate the steps by which the condition in *Dermochelys* was produced.

Protostega is the earliest of the definitely known forms. It is from the Upper Cretaceous (Niobrara) of Kansas. Similar in many respects to the recent *Dermochelys*, it still shows many primitive characters that indicate its separate position. The carapace was not ossified, but the proximal ends of the ribs show lateral expansions that would, if carried a little farther, produce the condition found in the *Chelonia* (the most primitive of the living sea turtles). The genus was one of the largest of the order. One specimen measured nearly or quite seven feet in length.

Protosphargis, from the Upper Cretaceous of Italy, *Eosphargis*, from the London Clay (Eocene), and *Psephophorous*, from the Miocene of Germany, are all closely related to *Protostega* and show successive steps toward the condition of *Dermochelys*. The great geographical extent of these forms seems to indicate that they possessed the same roving and pelagic habits that characterize their nearest living relative.

Remains of the closely related forms that culminated in the Cheloniidæ (*Chelonia*, etc.) and differed from the previous forms only in the more complete carapace, are found in the Cretaceous of Europe and America. These forms show characters of the land turtles as well as of the sea turtles, and are in all probability the forms that represent the branching of the primitive stem of the turtles. Such forms are *Propleura*, from the Cretaceous of New Jersey, *Osteopogys*, from the same locality, *Toxochelys*, from the Niobrara, Cretaceous, of Kansas, and *Euclastes* from the Cretaceous of New Jersey, the Greensand of Cambridge, England, the Eocene of England and France. Forms more common on the continent are *Eurysternum*, from the Upper Jurassic of Germany, *Idiochelys*, from the same horizon in France (Cerin) and Germany (Kelheim). *Hydropelta* is quite frequently found associated with the remains of *Idiochelys*.

Of the common swamp and land turtles more is known than of the sea turtles. The ancestors of the *Chelydridæ*, or common snapping turtles, are found as far back as the Upper Jurassic. *Platychelys* from this horizon, at Kelheim, is one of the typical forms. In *Platychelys* there was an extra pair of plates in the plastron, the mesoplastra, that did not reach the middle line from the sides.

Helochelys, from the Greensand (Cenomanian) of Kelheim, was quite similar to the preceding. The whole surface of the carapace was covered with wart-like projections, except the lines that marked the union of the horny plates with the bony ones beneath. In this form the mesoplastron was narrow but complete, and extended from each side, meeting in the middle line. It was quite large, about a foot and a half long.

Compsemys is a very large form, distinguished by the fact that the plates of the carapace are joined by suture to the peripherals, and are marked by small pit-like excavations. It is very plentiful in the Upper Cretaceous layers (Fort Union and Laramie) of the western part of this country.

Anostira was a small form from the Lowest Eocene (Bridger) in Wyoming.

Apholidomys and *Pseudotrionyx* are from the Eocene of France. The true land turtles, *Testudo*, mostly, are characterized by the great elevation of the carapace and the smoothness of its bones. The claws of the toes are in many cases shortened till they appear as broad nails. The earliest forms known are from the Eocene of Wyoming and New Mexico, the Wasatch and Bridger. In Europe the earliest forms occur in the Oligocene. Throughout the Miocene and the Pliocene layers of both the old and the new world, the genus abounds. The best region for the remains, however, is the Bad Lands of South Dakota, Miocene or Oligocene, where they occur in great abundance.

Especially remarkable was the gigantic *Collosochelys* of the Siwalik Hills of India (fresh-water Miocene). The animal was fully 18–20 feet long, the carapace alone being 12 feet long and 8 feet high.

From the Pleistocene of Queensland, Australia, comes the peculiar form *Meiolania*, which possessed horns or bony protuberances on the skull.

During Pleistocene times many of the islands of the East Indies were inhabited by enormous land turtles. Remains of such are known from Mauritius and Rodrigues. Similar remains are known from the Island of Malta and on the Galapagos Islands off the coast of Central America there are still living forms of the same group.

The *Pleurodira* are the forms in which the bones of the pelvis are joined by sutural union to the bones of the carapace and plastron above and below. They are few in number in recent times, and were little if any more numerous in past time, though, peculiarly enough, the most ancient turtle known is a member of this suborder. *Proganochelys*, from the Upper Triassic (Keupfersandstein) of Germany, *Plesiochelys*, from the Upper Jurassic of England, and *Bothremys*, of the New Jersey Cretaceous, are also members of the same group.

PROGANOSAURIA.

These forms are of the greatest interest from a phylogenetic standpoint. They are generally regarded as the most primitive form of the reptiles, and from them are probably derived the majority of the reptilian orders. They are characterized by a very generalized structure of the skull and skeleton that in many regards closely approximates the condition of the *Amphibia.* The bones were not completely ossified; there were many abdominal ossicles, and the vertebræ were perforated for the passage of the notochord. The group is extinct.

Paleohatteria, the earliest of the order, is found in the Rothliegende, Upper Permian, deposits of Niederhasslich near Dresden. It was a small lizard-like animal about a foot long; the teeth were small and conical, and were developed on the vomer and palatine bones of the mouth as well as in the jaws, a character common in the *Amphibia.*

Proterosaurus is another form much longer and more slender, about six feet in length. It is peculiar in the fact that the vertebræ of the neck are only seven in number, and are greatly elongated, as is common in the long-necked mammals. It is from the Keupferschiefer of Thuringia.

Mesosaurus, from the Permian or Permo-Triassic of South Africa, is represented by the impression of the anterior half of an animal that was much like the Plesiosaurs in general appearance; the neck was long and slender, and the head had the same kind of teeth. The posterior portion of an animal that is regared as belonging to the same genus has been found in the Permian of Brazil.

RHYNCHOCEPHALIA.

The members of this order differ only in degree from the preceding. The bones are better ossified; the abdominal ossicles are reduced in number and simplified in arrangement; the notochordal opening in the vertebræ is smaller and the skull has advanced toward the modern type of the reptiles. The group is of great importance, both because of the variety of the forms produced and because it is in all probability the direct ancestor of the later reptiles. The living *Lacertilia* and *Ophidia,* and, in all probability, the *Testudinata,* as well as the extinct *Plesiosaurs, Icthyosaurs, Pythonomorpha, Pterosauria, Dinosaurs, Croco-*

dilia, and possibly the *Theriodonta* must be regarded as the descendants of this order. Through the *Dinosaurs* the Birds are related to the order, and through the *Theriodonta* the Mammals.

Rhynchosaurus and *Hyperodapedon* are two forms from the Triassic, Elgin Sandstones of Scotland and the Triassic beds of Warwickshire in England. The latter genus has also been described from the Maleri, Triassic, beds of the East Indies. They were small forms, quite similar in external appearance to the modern lizard, except that the incisor teeth of the jaws were developed as great curved processes. The roof of the mouth was covered with teeth, and there was a single external nostril.

Homœosaurus and *Sapheosaurus* are from the Upper Jurassic of Germany and France, notably the Lithographic Slates of Kelheim. They were very similar to the modern lizards in appearance.

Sauranodon, from the Jurassic of Cerin in France, was similar to the foregoing, except that the jaws were greatly extended and were edentulous.

Champsosaurus, from the Upper Cretaceous, Laramie of Wyoming, and the lowest Eocene, Puerco of New Mexico, and *Simœdosaurus*, from the Eocene of France and Belgium, are very peculiar in that the articular faces of the vertebræ are nearly flat, instead of being deeply concave, or even perforated, as in the majority of the *Rhynchocephalia*. It has been suggested that the two forms are identical, but as the skull of *Champsosaurus* is not known it is impossible to settle the question. The skull of *Simœdosaurus* was long and slender, with an anterior rostrum much like that of the modern Gavial of the Indian rivers.

Sphenodon, from New Zealand, is the single living member of the order. It probably appeared in the Jurassic, though it is still unknown in the fossil state.

The modern *Lacertilia* and *Ophidia* are the direct descendants of the *Rhynchocephalia*. The chief differences are the loss of the lower one of the temporal arches (in some cases of both) and the loss of the abdominal ossicles. Moreover, the deeply biconcave character of the vertebræ, amounting in most cases to a perforation of the centrum, is absent in most of the *Lacertilia* and all of the *Ophidia*. The loss of the limbs in the snake is but a secondary character, and is nearly accomplished in many genera of the lizards.

The earliest of the *Lacertilia* is from the Isle of Purbeck in Dorsetshire, England. All that is known of the specimen are the imperfectly preserved remains of the skull and some of the scales. The genus is called *Macellodon*.

Hydrosaurus, from the Lower Cretaceous of the Island of Lesina in the Mediterranean, was very similar in appearance to the modern monitors. (This genus was the direct ancestor of the great, specialized group of the *Pythonomorpha* developed during the Cretaceous.)

Dolichosaurus and *Coniosaurus*, from the Upper Cretaceous of England, and *Tylosteus*, from the Cretaceous of North America, are typical lacertilians. The Tertiary rocks of both hemispheres abound in the remains of the *Lacertilia*. The development of these forms began so early that even in the earliest Eocene we find representatives of the families and even of the genera of today. Zittel in his *Handbuch* enumerates from the Eocene of Wyoming the remains of *Chameleo*, *Iguanavus*, *Glyptosaurus*, *Saniva*, *Xestops*, *Thinosaurus*, and *Tinosaurus;* from the Eocene Phosphorite (Upper Eocene) of Quercy, *Agama*, several genera of the *Iguanidæ*, *Paleovaranus*, and *Lacerta*.

In the Miocene deposits of Europe are found many of the existing genera. In the Miocene of the western states, especially Colorado, are found such genera as *Exostinos*, *Aciprion*, *Diacium*, *Platyrachis*, and *Crematosaurus*.

Most of the remains of the Pliocene and the Pleistocene formations belong to existing genera and species, with the exception of the Australian *Megalania* and *Notiosaurus*.

The *Ophidia* are very poorly known from the fossil forms. The only parts preserved are the vertebræ. With the single exception of *Symoliophis*, from the Cretaceous of Charente, the known fossils are from the Tertiary layers. From the London Clay (Eocene) and the Eocene sand of France come the remains of large Python-like forms. The Eocene of New Jersey has yielded one form, *Titanophis*, and the Puerco of New Mexico *Helegras*. The Eocene of Wyoming has yielded *Boavus*, *Lithophis*, and *Limnophis*.

The Miocene layers of both this country and Europe have afforded many scattered fragments that belong mostly to living families. The Pliocene and the Pleistocene contain only genera and species of living forms.

CROCODILIA.

The *Crocodilia* are lizard-like forms of generally, large size possessing many characters that indicate their origin from the *Dinosaurs* and the *Rhynchocephalia*. The tail is long and powerful, the jaws armed with strong, simple teeth, the skull flattened, and the anterior end produced into a rostrum of varying length; there is generally developed in the skin a series of bony plates that in some forms is confined to the back, and in others extends to the skin of the abdomen as well; there are generally developed abdominal ribs in the body wall.

The order is divided by Zittel into three suborders:

Parasuchia.
Pseudosuchia.
Eusuchia.

The *Parasuchia* are the nearest of all the order to the ancestral stem of the *Crocodilia*. The possession of paired anterior nares, located far back on the upper surface of the skull, of large preorbital openings in the skull; the structure of the base of the skull and the palatal region, and the structure of the shoulder girdle are all characters that unite the suborder with *Dinosaurs* and the *Rhynchocephalia*.

Belodon, the most common form, was about nine feet long; the skull extended forward in a long, high, and laterally compressed rostrum; the jaws were filled with strong, simple teeth; there were two rows of plates extending down the middle of the back, and others less regularly developed in the skin of the sides; the limbs were weak and probably had about the same proportions as in the modern Crocodile. Remains of the genus are known from the Trias of Germany, and from the same horizon in both the eastern and western parts of the United States.

Stagonolepis and *Parasuchus* are forms separated from the foregoing by minor characters of the skull and teeth. The first is known from the Triassic (?) Elgin Sandstones of Scotland, and the latter from the same horizon, Maleri Sandstone of the East Indies.

Pseudosuchia.—These are very peculiar forms from the Triassic rocks; the genera were all small, not over a foot long at the outside; the most characteristic thing about them was the development of a cuirass of bony plates in the skin, that protected every part of the body from the head to the tail, and included the ventral as well as the dorsal side of the body.

Ætosaurus, from the vicinity of Stuttgart in Germany, is the best known form. A single slab in the Stuttgart Museum has the remains of twenty-four individuals preserved in it.

Typothorax is the name given to a form described by Cope from fragments of the ribs and the dermal plates discovered in the Triassic rocks of New Mexico.

Eusuchia.—This suborder is in general characterized by the shortness of the premaxillaries and the location of the external nares far forward on the snout; the roofing over of the palatal portion of the mouth by the gradual extension inward of the palatine and maxillary bones, and the crowding of the internal nares back toward the posterior part of the mouth. There are two sections described, the *Longirostres* and the *Brevirostres;* the first possesses a long, slender rostrum formed by the extension of the maxillary bones; the anterior nares are not divided at the anterior extremity, and the teeth are little differentiated. The *Brevirostres* have a short snout, with the anterior nares divided, and the teeth more or less differentiated.

The *Longirostres* contain several families, typical of which are the *Teleosauridæ* and the *Gavialidæ.* The *Teleosauridæ* are the oldest known of the *Eusuchia*, specimens being known from the Lias. The oldest of the forms were marine, and the latter inhabited fresh water. They were powerful swimmers, with much better developed limbs than the modern Crocodiles. The skin of both the back and abdomen was strengthened by the presence of bony plates that formed a very perfect armor. Prominent forms were *Pelagosaurus* from the Upper Lias of Germany and France; *Mystriosaurus*, from the same horizon in Germany; *Steneosaurus*, from the Upper Jurassic of England and the continent; *Teleosaurus*, from the same horizon and localities, etc. Many genera are known from layers younger than the Jurassic, and these seem to lead naturally to the *Gavialidæ*, which are known from the late Tertiary of India, and are found living in the rivers of that country.

The *Brevirostres* became prominent in the Upper Jurassic, and occupied a very important part in the later times. Of five families described two are still living.

Alligatorellus was a small form from the Upper Jurassic of France; it was less than a foot long, and was characterized by the possession of biconcave vertebræ.

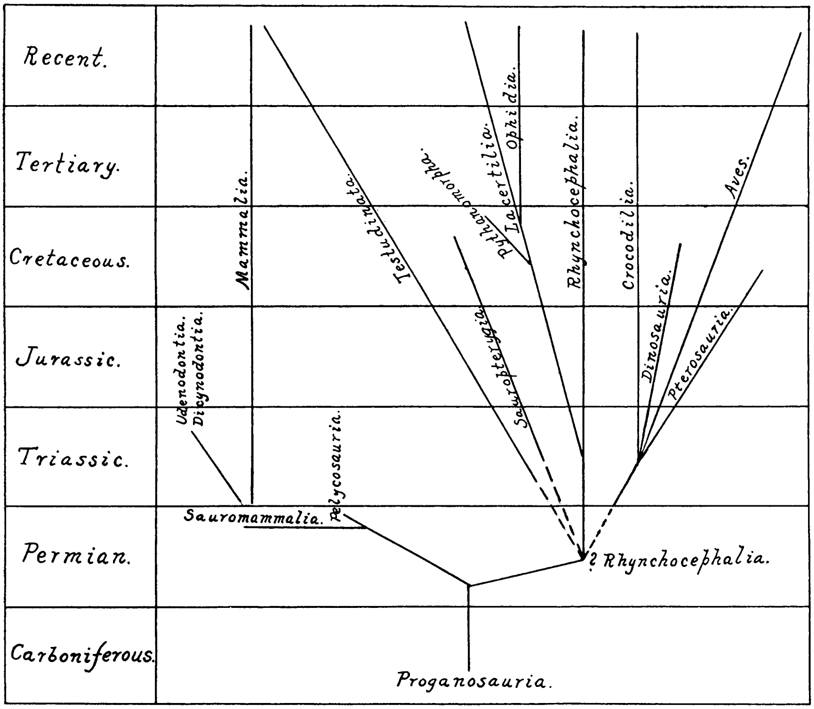
Goniopholis, from the Upper Jurassic of England and the continent, was a much larger form than the preceding. It possessed biconcave vertebræ; there was a double line of dermal plates in the skin of the back, and the ventral surface of the body was protected by a large number of plates joined by suture. Similar forms have been described by Cope and Marsh, from the Jura of the Rocky Mountains, under the names *Amphicotylus* and *Diplosaurus*. These may be synonymous with *Goniopholis*.

Bernissartia is from the celebrated fossil region near Bernissart in Belgium. It is characterized by the fact that the teeth are differentiated into separate sizes in the jaws. *Theriosuchus*, from the Purbeck of England, is regarded as belonging to the same family.

The true Alligators and Crocodiles appeared in the fresh water deposits of the Cretaceous and extended to the present time. *Diplocynodon* is one of the earliest of the true Alligators. Remains are found in the deposits of both Europe and North America.

The genus *Crocodilus* appeared in the Cretaceous of France. Remains are known from the Tertiary deposits of both the old and the new worlds as late as Pliocene time, when they seem to have disappeared from all regions except those in which they are still found, tropical Africa, South America, and the East Indies.

The connection between the various groups of reptiles may be seen from the following table, which is slightly modified from one published by Baur.



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